AMENDMENTS TO CLAIMS

# WE CLAIM:

1. (canceled) rewritten/re-presented in claim 5
2. (canceled) rewritten/re-presented in claim 6
3. (canceled) rewritten/re-presented in claim 7
4. (canceled) rewritten/re-presented in claim 8
5. (re-presented - formerly independent claim 1) A method of recognizing subsequences represented as Hidden Markov Models (HMM) (which can be obtained from equivalent DTW models or generalized profiles) that are searched for in a given sequence, characterized by:

   - the use of a confidence measure based on
     - the accumulated posterior, normalized with the length of the matched subsequence $X_b^e$ (aka. 'simple normalization')

       $$\frac{-1}{e-b+1}\log P(Q|X_b^e)$$

     - or, defining phonemes as partitions of states in a HMM,
       * the extremes of the values of the logarithm of the accumulated posterior in each phoneme, normalized with its length, called 'real fitting',

         $$\max_{phoneme \in Visited\ Phonemes} \frac{\sum_{phoneme} -\log(posteriors)}{phoneme\ length}$$

       * or double normalization of the accumulated posterior over the number of phonemes, J, and over the number of acoustic samples, $e_j - b_j + 1$ in each phoneme, $j$,

         $$\frac{-1}{J}\sum_{j=1}^{J}\left(\frac{1}{e_j-b_j+1}\sum_{n=b_j}^{e_j}\log P(q_j^n|x_n)\right)$$

   - and by the fact that it searches the subsequences that offer the maximization of one mentioned confidence measures, over all possible matchings,

- and allows for the eventual revaluation of the alternatives that offer the highest scores of a mentioned confidence measure on the basis of another confidence measure,

- and when based on the confidence measure called 'simple normalization' uses a method that we call 'Iterative Viterbi Decoding', that estimates the emission probability of the filler states in an iterative manner as being equal to the confidence measure in the previous iteration,

  and where the emission probability in the filler states in the first iteration can be initialized to anything, but the iteration stops

  - at convergence yielding the estimation of a keyword's boundaries and score as the obtained boundaries and score of non-filler states of the HMM,
  - or when the confidence measure descends under a threshold value, T, estimating only the keyword existence,
  - or when the emission probability of filler states, $\varepsilon_0$ is initialized with T as is reestimated, as value of $\varepsilon_1$ at the end of the first iteration, to be higher than T deciding keyword inexistence.

- or for any of the three confidence measures: 'simple normalization', 'double normalization' or 'real fitting', uses a beam-search-like algorithm that considers the emission probability of the filler state as zero, computes progressively for each pair of sample and state of HMM a set of possible alternatives paths to reach it, the computation of this set is based on the sets of paths that lead to the states that can be associated to the previous sample and extended with transitions allowed by the analyzed HMM,

  where this set can be reduced by using appropriate (safe) rules for the given confidence measure, ensuring the correctness of the inference,

  and where this set can be also reduced by using heuristics, for speeding up the computation despite the risk of reducing the theoretical quality of the recognition, heuristics of which a fast version stores only the best match,

and for all confidence measures one can prune the set of alternatives with safe rules guaranteeing optimality, where:

- the 'simple normalization' confidence measure with beam-search is used with a safe pruning that discards a path $Q_1$ given the existence of a path $Q_2$ whenever $S_2 < S_1$ and $L_1 < L2$, where $S_1$ and $L_1$ respectively $S_2$ and $L_2$ are the minus of the cumulated log of posteriors along the paths, and the lengths of the paths, for the paths $Q_1$ respectively $Q_2$, and which can be optimized by sorting competing paths based on their cost

- the 'double normalization' confidence measure on HMMs where no path skips any phoneme is used with a safe pruning that discards a path $Q_1$ given the existence of a path $Q_2$ whenever one of the following tests succeed:

  (a) $l_2 \geq l_1$, $A > 0$, $B \leq 0$ and $L_c^2 A + L_c B + C \geq 0$

  (b) $l_2 \geq l_1$, $A \geq 0$, $B \geq 0$ and $C \geq 0$

  (c) $l_2 \geq l_1$, $A \leq 0$, $C \geq 0$ and $L^2 A + LB + C \geq 0$

  (d) $l_2 \geq l_1$, $A = 0$, $B < 0$ and $LB + C \geq 0$

  where we denote by $a_1$, $p_1$, $l_1$, respectively by $a_2$, $p_2$ and $l_2$ the confidence measure for the previously visited phonemes, the posterior in the current phoneme and the length in the current phoneme for the path $Q_1$, respectively the path $Q_2$, and we also use the notations $A = a_1 - a_2$, $B = (a_1 - a_2)(l_1 + l_2) + p_1 - p_2$, C$=(a_1 - a_2)l_1 l_2 + p_1 l_2 - p_2 l_1$, $L = L_{max} - \max\{l_1, l_2\}$, $L_c = -B/2A$ and $L_{max}$ is the maximum acceptable length for a phoneme,

- the 'double normalization' confidence measure on HMMs where some paths skip phonemes is used with a safe pruning that discards a path $Q_1$ given the existence of a path $Q_2$ whenever $l_2 \geq l_1$, $A \geq 0$, $p_1 \geq p_2$ respectively $F_2 \geq F_1$,

  where $F_1$ respectively $F_2$ are the number of visited phonemes for paths $Q_1$ and $Q_2$,

- the 'real fitting' is used with the safe pruning: $Q_2$ is discarded in favor of another path $Q_1$ if the confidence measure of the Real Fitting for the previous phonemes

is inferior (higher in value) for $Q_2$ compared with $Q_1$, and if $p_1 \leq p_2$ and $l_2 \leq l_1$, where $p_1$, $l_1$, respectively $p_2$, $l_2$ represent the minus of the logarithm of the cumulated posterior respectively the number of frames in the current phoneme for the path $Q_1$ respectively $Q_2$,

- and besides the previously mentioned safe pruning, heuristic prunings are also used for removing paths when $p > L_{max}P_{max}$ in any state or when $\frac{p}{l} > P_{max}$ at the output from a phoneme,

  where p and l are the values in the current phoneme for the minus of the logarithm of cumulated posterior and for the length of the path that is discarded.

6. (re-presented - formerly dependent claim 2) The method of claim 5, where the method is used to estimate the existence of keywords and their position in utterances, using Hidden Markov Models that model keywords.

7. (re-presented - formerly dependent claim 3) The method of claim 5, where the method is used to estimate the existence of biomolecular subsequences and their position in the chains of DNA using hidden Markov models to model the searched subsequences, and where these models can be obtained by trivial translation from generalized profiles.

8. (re-presented - formerly dependent claim 4) The method of claim 5, where it carries out the estimation of the existence of objects and their position in images, characterized by the fact that

   - it uses models of objects as subsequences represented by Hidden Markov Models,
   - namely sections through views of objects are modeled by Hidden Markov Models,
   - it uses emission probabilities based on a distance computed between colors, simple distances being yield by a Gaussian with median at the target color, or a normalized inverse of the Euclidean distance in the RGB space,
   - wherein the Hidden Markov Models that model the objects can be structured of distinct regions, that play in the frame of the method the role of the phonemes in claim 1,

- and wherein the models of the objects can be modified in a dynamic manner during decoding with respect to the transition properties (existence and probability) on the basis of the so far accumulated information in the process.